

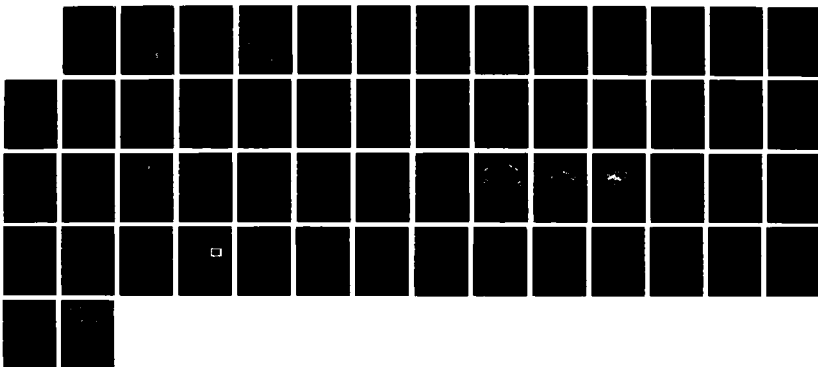
AD-A190 900

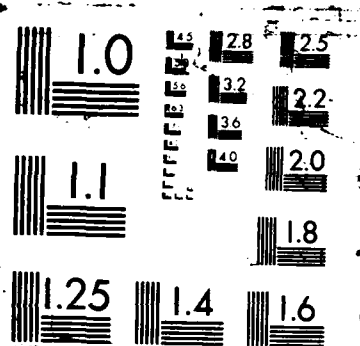
DNA SCILS PROGRAM (SURVIVABLE COMMAND INFORMATION AND
LIAISON SYSTEM)(U) R AND D ASSOCIATES MARINA DEL REY CA
G A GORDON 30 MAY 86 RDA-TR-125300-005 DNA-TR-86-203
DNA001-83-C-0032 F/G 25/5

1/1

UNCLASSIFIED

NL





4

AD-A190 900

DTIC FILE COPY

DNA-TR-86-203

DNA SCILS PROGRAM (SURVIVABLE COMMAND INFORMATION AND LIAISON SYSTEM)

**G. A. Gordon
R&D Associates
P.O. Box 9695
Marina del Rey, CA 90295**

30 May 1986

Technical Report

CONTRACT No. DNA 001-83-C-0032

**Approved for public release;
distribution is unlimited.**

THIS WORK WAS SPONSORED BY THE DEFENSE NUCLEAR AGENCY
UNDER RDT&E RMSS CODE B385085466 099QMXCA00001 H2590D.

**DTIC
ELECTE
S JAN 25 1988
CAH**

**Prepared for
Director
DEFENSE NUCLEAR AGENCY
Washington, DC 20305-1000**

**DTIC
AD-A190 900
AL**

DISTRIBUTION LIST UPDATE

This mailer is provided to enable DNA to maintain current distribution lists for reports. We would appreciate your providing the requested information.

- ☐ Add the individual listed to your distribution list.
- ☐ Delete the cited organization/individual.
- ☐ Change of address.

NAME: _____

ORGANIZATION: _____

OLD ADDRESS

CURRENT ADDRESS

TELEPHONE NUMBER: () _____

SUBJECT AREA(s) OF INTEREST:

DNA OR OTHER GOVERNMENT CONTRACT NUMBER: _____

CERTIFICATION OF NEED-TO-KNOW BY GOVERNMENT SPONSOR (if other than DNA):

SPONSORING ORGANIZATION: _____

CONTRACTING OFFICER OR REPRESENTATIVE: _____

SIGNATURE: _____

CUT HERE AND RETURN



Director
Defense Nuclear Agency
ATTN: [REDACTED] TITL
Washington, DC 20305-1000

Director
Defense Nuclear Agency
ATTN: [REDACTED] TITL
Washington, DC 20305-1000

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE

A190900

REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED			1b. RESTRICTIVE MARKINGS		
2a. SECURITY CLASSIFICATION AUTHORITY N/A since Unclassified			3. DISTRIBUTION/AVAILABILITY OF REPORT Approved for public release; distribution is unlimited.		
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE N/A since Unclassified					
4. PERFORMING ORGANIZATION REPORT NUMBER(S) RDA-TR-125300-005			5. MONITORING ORGANIZATION REPORT NUMBER(S) DNA-TR-86-203		
6a. NAME OF PERFORMING ORGANIZATION R & D Associates		6b. OFFICE SYMBOL (If applicable)		7a. NAME OF MONITORING ORGANIZATION Director Defense Nuclear Agency	
6c. ADDRESS (City, State and ZIP Code) P.O. Box 9695 Marina del Rey, CA 90295			7b. ADDRESS (City, State and ZIP Code) Washington, DC 20305-1000		
8a. NAME OF FUNDING/SPONSORING ORGANIZATION		8b. OFFICE SYMBOL (If applicable) NANF/Providakes		9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER DNA 001-83-C-0032	
8c. ADDRESS (City, State and ZIP Code)			10. SOURCE OF FUNDING NUMBERS		
			PROGRAM ELEMENT NO. 62715H	PROJECT NO. 099QMXC	TASK NO. A
11. TITLE (Include Security Classification) DNA SCILS PROGRAM (SURVIVABLE COMMAND INFORMATION AND LIAISON SYSTEM)					
12. PERSONAL AUTHOR(S) Gordon, Gary A.					
13a. TYPE OF REPORT Technical		13b. TIME COVERED FROM 821130 TO 860530		14. DATE OF REPORT (Year, Month, Day) 860530	
15. PAGE COUNT 54					
16. SUPPLEMENTARY NOTATION This work was sponsored by the Defense Nuclear Agency under RDT&E RMSS Code B385085466 099QMXCA00001 H2590D.					
17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number) Dispersed Command, Computer Conferencing, Data Networking		
FIELD	GROUP	SUB-GROUP			
12	7				
25	3				
19. ABSTRACT (Continue on reverse if necessary and identify by block number) The SCILS program was undertaken by DNA in order to investigate and demonstrate concepts of operation for dispersed theater forces C ³ . The dispersal concept would increase the number of potential targets for nuclear strike, make these targets smaller, more highly mobile and harder to find, and introduce functional redundancy. The SCILS system is a micro-computer based approach to preserving and enhancing the effectiveness of C ³ operation in a dispersed configuration. In this program, the system was implemented for testing for the 9th Infantry Division at Fort Lewis, WA in coordination with the Army's Distributed Command and Control System. Technical highlights of the system include a distributed, replicated data base, a video map/graphics-oriented "Commander's Decision Display System," a packet-switched "Multi-Media Network" that operates with deployed field communication systems, and a "Voice/Data Conferencing System" that supports remote coordination/briefing in a dispersed configuration. The program and resulting system are discussed in this report.					
20. DISTRIBUTION/AVAILABILITY OF ABSTRACT <input type="checkbox"/> UNCLASSIFIED/UNLIMITED <input checked="" type="checkbox"/> SAME AS RPT. <input type="checkbox"/> OTIC USERS			21. ABSTRACT SECURITY CLASSIFICATION UNCLASSIFIED		
22a. NAME OF RESPONSIBLE INDIVIDUAL Sandra E. Young			22b. TELEPHONE (Include Area Code) (202) 325-7042		22c. OFFICE SYMBOL DNA/CST1

DD FORM 1473, 84 MAR

83 APR edition may be used until exhausted.
All other editions are obsolete.UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE

A-1

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (when data entered)



UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (when data entered)

EXECUTIVE SUMMARY

Chart 1. SCILS program overview.

- MOTIVATION

- ENHANCE NUCLEAR SURVIVABILITY AND EFFECTIVENESS OF THEATER FORCES C³ ON INTEGRATED BATTLEFIELD

- DESCRIPTION

- EXPERIMENTAL PROGRAM TO INVESTIGATE AND DEMONSTRATE CONCEPTS OF OPERATION FOR DISPERSED DIVISION C³ OPERATION
- EMPHASIS ON DATA CONNECTIVITY ASPECTS

- LOCATION AT FT. LEWIS

- SYNERGISM WITH ARMY DCCS PROGRAM
- OPPORTUNITY TO IMPACT ARMY C³ DEVELOPMENT

This section provides an overview of the Survivable Command Information and Liaison System (SCILS) program, its objectives, the impact that the program has had on survivability and effectiveness for ground forces C³, and conclusions.

This first chart provides an overview of the SCILS program. The motivation for the program derived from DNA's concern with the survivability of theater forces C³ on the integrated battlefield. Through a series of studies, DNA had concluded that survivability of C³ headquarters on the integrated battlefield of the future would probably require the ability to operate in a dispersed configuration. This approach would increase the number of potential targets for nuclear strike, make these targets smaller, more highly mobile and harder to find, and introduce functional redundancy so that loss of some of these assets could be tolerated. However, it was not clear how operation in a dispersed configuration, consistent with survivability, could be achieved without serious sacrifices in the effectiveness of C³ operation.

Thus, the SCILS program was undertaken by DNA in order to investigate and demonstrate concepts of operation for dispersed theater forces C³. Since the effective use of modern automation technology and data networking was considered to be essential to the success of this approach, emphasis was placed on the data processing and connectivity aspects of the program.

Although DNA's interest was stimulated primarily by consideration of the potential NATO battlefield, the program test bed was located at Fort Lewis in order to take advantage of a potential synergism with an emerging Army program known as the Distributed Command and Control System (DCCS). The technical requirements of Divisional C³ operation were considered to be sufficiently similar to those of higher echelons in order to accomplish DNA's principal objective of stimulating initiatives for nuclear survivable C³ for the forces in the European Theater. At the same time, the program offered the opportunity to impact the development of U.S. Army C³ in a direction which would lead to enhanced survivability and effectiveness on the integrated battlefield. While DNA's investment in this program was quite substantial, the close coordination with the much larger Army DCCS program enabled DNA to achieve its goals in this program with an efficiency and effectiveness that would not have been possible had DNA undertaken the program without such Army involvement.

Chart 2. SCIL technical goals.

● OVERALL GOAL

- SUPPORT INFORMATION PROCESSING AND DATA CONNECTIVITY REQUIREMENTS FOR C³ OPERATION IN A DISPERSED CONFIGURATION

● TECHNICAL HIGHLIGHTS

- DISTRIBUTED, REPLICATED, RELATIONAL DATA BASE
- COMMANDER'S DECISION DISPLAY SYSTEM
- VOICE/DATA CONFERENCING SYSTEM
- PACKET-SWITCHED DATA NETWORKING WITH MIXED MEANS (INCLUDING SINGLE-CHANNEL RADIO)
- HIGHLY USER-FRIENDLY MAN/MACHINE INTERFACE

This figure outlines the technical goals of the SCILS program. From a technical standpoint, the overall goal of the SCILS program was to support the information processing and data connectivity requirements for operation of the C³ forces of the 9th ID in a dispersed configuration. This top level goal gave rise to a set of specific technical goals for the program, particularly with regard to software development aspects.

First, in order to avoid the possibility that loss of a subset of the division's C³ assets would result in the loss of critical information required for C³ operations, the SCILS system supports a distributed, replicated, relational data base. In this data base system, the essential elements of information, once generated and entered into the system, are automatically distributed to a large number of redundant C³ locations throughout the battlefield. This is done in a matter transparent to the system operators so that no additional burden is placed on them to achieve this redundancy. As a consequence of this approach, the Commander and his staff can exercise command and control from a large number (typically 14) of locations around the battlefield

with equal effectiveness, since the information they needed to exercise such control is present at any one of these locations.

Rather than displaying raw information from the data base, the system was developed to include a Commander's Decision Display System. This display system, primarily graphical in orientation, was designed in close collaboration with the 9th ID's command staff, and presents a comprehensive view of the division status in a top-down fashion, from the division level down to the company level.

A major disadvantage of C³ operation in a dispersed configuration was conceived to be the diminished opportunity for the Commander and his staff to work together and exchange information face-to-face, such as is generally possible in a consolidated configuration. A principal tool de-developed in the SCILS system to address this problem is the voice/data conferencing system. With this system, the command staff can exchange information verbally while using a highly sophisticated data connectivity approach to enhance the coordination process.

The SCILS system, as used by the 9th ID, is required to operate exclusively with the 9th ID's organic communication systems, which consist of principally a multi-channel phone system and VHF/FM single channel radios. In the SCILS system, we use these organic assets in a highly sophisticated manner based on packet-switched data networking. This approach is consistent with the highly dynamic nature of the battlefield, and provides robust connectivity in the presence of unavoidable attrition of system assets.

Finally, the system was developed with a highly user-friendly man/machine interface, suitable for operation by the soldier in the field. As part of this program, 9th ID operators have been trained to use the system, and have used and continue to use the system on an ongoing basis for their exercise support.

Chart 3. SCILS impact on army-wide C³.

● A FOUR-STEP PROCESS

- (1) SCILS CAPABILITIES ARE DEMONSTRATED AND ADOPTED AS DCCS GOALS BY ARMY (9th ID AND ADEA MAKE DECISION)
- (2) SCILS CAPABILITIES ARE INTEGRATED INTO DCCS FOR TESTING IN CPX/FTX ENVIRONMENTS
- (3) PROVEN CAPABILITIES ARE ADOPTED BY OPERATIONAL DCCS SYSTEM
- (4) THROUGH DCCS/MCS HARMONIZATION ACTIVITIES THE CAPABILITIES BECOME PART OF ARMY-WIDE MANEUVER CONTROL SYSTEM

The SCILS program has had a major impact on Army-wide C³ through a four-step process outlined on this figure. In this process, technical capabilities developed in the SCILS program have been demonstrated to the Army and (in almost all cases) ultimately adopted as goals for the DCCS system. This decision is made jointly by the 9th ID and ADEA (Army Development and Employment Agency) at Fort Lewis.

Once adopted as goals, the SCILS capabilities were then patched into the DCCS so that they could be tried in the ongoing testing in CPX and FTX environments.

Once proven in the operational environment, the technical capabilities were then selected for integration into the operational DCCS system. At this point, additional work was performed as necessary to make the system features more robust and supportable and to document them to the level required for the operational system. (This latter integration effort was primarily supported by Army funding.)

The U.S. Army considers the DCCS system at the 9th ID to be an important test bed relevant to the ongoing development of the Army-wide Maneuver Control System (MCS). Through DCCS/MCS harmonization activities, any capabilities proven to be feasible and effective in DCCS operations are adopted for goals for the Army-wide MCS system.

Through the above process, the SCILS program has had a clear and acknowledged impact on the survivability and effectiveness of ground forces C³ throughout the U.S. Army.

Chart 4. Conclusions.

- ALL TECHNICAL GOALS OF PROGRAM ACHIEVED
- MAJOR IMPACT ON ARMY C³ ACCOMPLISHED
 - DISTRIBUTED DATA BASE AND COMMANDER'S DISPLAY SYSTEMS INTEGRATED INTO DCCS
 - CONFERENCING AND NETWORKING SYSTEMS ADOPTED AS GOALS TO BE FULLY INTEGRATED INTO DCCS
- SCILS CONFERENCING AND NETWORKING SYSTEMS ADOPTED AS BASELINE SYSTEMS FOR 9th ID CPX/FTX OPERATIONS
- FUNDING LIMITS HAVE DELAYED COMPLETING SCILS INTEGRATION INTO DCCS AND UPGRADING SYSTEM SPECS FOR INCREASED ROBUSTNESS
- DEVELOPED SCILS CAPABILITIES HAVE ADVANCED THE STATE OF ART FOR SURVIVABLE AND EFFECTIVE GROUND FORCES C³

Essentially all of the technical goals established for the SCILS program have been achieved, and the program has clearly had a major impact on Army C³ development. Two of the early goals of the SCILS program were the distributed data base system and the Commander's Decision Display System. This work, which was closely coordinated with related work performed with Army funding, has already been fully integrated into the DCCS system. (A disadvantage of this early and total assimilation is that few in the Army at this time still remember the major contribution made by DNA to these capabilities.) The SCILS conferencing and networking systems were more technically ambitious goals of the program, and were consequently later in development. These latter capabilities have now been fully demonstrated in both experimental and operational environments, and have been adopted as goals to be fully integrated into the DCCS operational system. In fact, the SCILS conferencing and networking systems are considered by the 9th ID to be their baseline system for continuing CPX and FTX operations.

As is always the case in high-technology experimental systems of this type, there is more work to be done in order to make the system sufficiently robust for routine use in either exercise or operational environments. In particular, it has been recognized that a number of changes in the system-tem specifications are desirable for increasing the robust-ness of system operation. Despite this, it is already clear that the capabilities developed in SCILS have advanced the state-of-the-art for survivable and effective ground forces C³.

TABLE OF CONTENTS

Section		Page
	EXECUTIVE SUMMARY	iii
	LIST OF ILLUSTRATIONS	xii
1	BACKGROUND	1
2	IMPLEMENTATION FOR 9TH ID AT FORT LEWIS	9
3	TECHNICAL OVERVIEW OF THE SCILS SYSTEM	22

LIST OF ILLUSTRATIONS

Chart		Page
1	SCILS Program Overview	iii
2	SCILS Technical Goals	v
3	SCILS Impact on Army-Wide C ³	vii
4	Conclusions	ix
5	The Problem: C ³ Survivability on Integrated Battlefield	1
6	The Solution: Dispersed Command Posts A Multi-Faceted Approach to Survivability	3
7	To Retain and Enhance CP Effectiveness	4
8	Emphasis On Single-Channel Radio Use	6
9	Typical Echelon Above Corps Configuration (SHAPE, MSC, PSC)	8
10	Division Dispersed CP Program	9
11	SCILS Configuration	11
12	SCILS/DCCS Capabilities Development	12
13	Integrated Software Architecture	13
14	DCCS And The Command And Control Architecture	14
15	Hardware Allocation (9th ID)	15
16	SCILS/DCCS Information Flow	16
17	SCILS/DCCS Relational Data Base Management System	17
18	Integrated Command Post - Modular Concept	18

LIST OF ILLUSTRATIONS (Concluded)

Chart		Page
19	ICP Vehicle Configuration	19
20	Commander's Battle Center	20
21	SCILS Evolution Plan	21
22	SCILS Technical Highlights	22
23	SCILS ADP Configuration	24
24	WICAT System 161 Characteristics	26
25	Voice/Data Conferencing	27
26	Voice/Data Conferencing (Continued)	29
27	Multi-Media Network	31
28	Internal Network	33
29	SCILS Communications Front End (CFE)	35
30	Conclusions and Recommendations	36

SECTION 1

BACKGROUND

Chart 5. The problem: C³ survivability on integrated battlefield.

- PRESENT COMMAND POSTS ARE
 - TOO LARGE
 - TOO BUSY
 - TOO VISIBLE
 - TOO FEW
- RELATIVELY FEW TARGETS INVITE DECAPITATING NUCLEAR STRIKE
 - HARDENING INSUFFICIENT
- MANY COMMUNICATIONS MEANS ARE VULNERABLE IN NUCLEAR WAR

Survivability of the NATO forces on an integrated European battlefield has been an ongoing concern of the Defense Nuclear Agency for many years. As one element of this concern, it was recognized that the NATO C³ forces were a highly attractive and probably high-priority target for the Warsaw Pact Forces. The SCILS program arose at DNA as one of a series of study and experimental programs designed to address this concern. This background is discussed in the next series of charts.

There is a widespread recognition that the present NATO Command Posts from SHAPE on down are too large, too easy to find, and so few in number that they might be considered to invite a decapitating nuclear strike. With relatively few nuclear weapons, and consequently with limited collateral damage, the Warsaw Pact could, in principle, destroy a major portion of the NATO Command structure. In this age of ever-increasing accuracies, hardening of the command headquarters is not a viable

approach in itself. Finally, in addition to the obvious vulnerability of the headquarters themselves, the communication systems that they use are also collateral nuclear effects such as EMP and atmospheric disturbances.

Chart 6. The solution: Dispersed command posts
a multi-faceted approach to survivability.

- DIVIDE CP INTO SEVERAL CELLS
- SEPARATE CELLS BY SAFE DISTANCES
- MAKE CELLS HARD TO FIND
- PROVIDE FOR RAPID RELOCATION OF CELLS
- INTRODUCE MUTUAL CELL FUNCTIONAL REDUNDANCY
- USE SURVIVABLE COMMUNICATIONS

As a result of several studies performed by DNA and others, it became clear that survivability on the integrated battlefield would require a multi-faceted approach. A key element of this approach was dispersal of the C³ headquarters; that is, to divide the rather large command posts used presently by the NATO Echelons Above Corps (EAC) into a number of cells which could then be separated by nuclear safe distances. In addition to their reduced size, other means such as signature suppression would be used to make the cells harder to find. They would also be made more highly mobile so that, even when found, it would be more likely that they would move before any enemy attack would arrive. Since it is inevitable that some number of these cells would be lost to enemy action, it is also necessary to introduce a degree of mutual cell functional redundancy so that, if a cell were lost, its function could be taken over by one or more of the redundant cells. Finally, the system would use multiple, redundant communication systems to maintain connectivity and, where possible, these communication systems would be hardened against nuclear effects such as EMP.

Chart 7. To retain and enhance CP effectiveness.

- ADP EQUIPMENT TO SUPPORT INFORMATION REQUIREMENTS
(INCLUDING BATTLEFIELD DATA AND MAP POSTING)
- DIGITAL CONNECTIVITY TO DISTRIBUTE CRITICAL DATA
- VOICE/GRAPHICS CONFERENCING

When a command post is divided into a number of dispersed cells, the concern that arises immediately is the impact that this might have on the effectiveness of the C³ operators and the command staff in performing their functions. A key element of the SCILS approach to addressing these concerns was the extensive use of ADP equipment to support the information requirements of the command staff. It was hoped that the largely manual procedures used today for maintaining battlefield data and for map posting could be replaced largely by procedures based on the ADP system. Hopefully, this would result in a more timely and accurate picture of the battlefield than is currently available. In addition, it seems conceivable, at least, that by eliminating some of these clerical jobs the overall size of the command staff could be reduced, which would promote the additional survivability goals of decreased size and increased mobility.

A second element of the SCILS technical approach to enhancing the effectiveness of command post operations was the use of digital connectivity to distribute necessary data. Currently, this information is distributed to a great extent by verbal means over available telephone systems. In many instances this proves to be extremely slow and inefficient compared to digital means which are capable of transmitting the same information in a much shorter time when a connection becomes available.

The final element in the SCILS technical approach to enhanced C³ effectiveness was the use of a voice/data conferencing

system to compensate, at least in part, for the decreased opportunity in a dispersed configuration for face-to-face interaction among the command staff. The voice/data conferencing system operates to some extent in a manner similar to the closed circuit TV (CCTV) systems used in several early dispersed-CP experiments. In SCILS, however, the same ADP equipment used to meet the information and digital connectivity requirements of the command staff is also used to provide a sophisticated conferencing tool. This approach is also consistent with the voice bandwidth communication systems and encryption largely available on the battlefield today. CCTV systems, on the other hand, appeared to introduce formidable communications and encryption problems due to the wide bandwidths involved.

Chart 8. Emphasis on single-channel radio use.

● **SURVIVABILITY ADVANTAGES**

- MAXIMIZES MOBILITY AND SITING FLEXIBILITY OF CELLS
- EQUIPMENT AMENABLE TO EMP TREATMENT
- USERS FIND SAFETY IN NUMBERS (EVEN BETTER WITH FREQUENCY HOPPING/ENCRYPTION)

● **MULTICHANNEL PHONE SYSTEM HAS PROBLEMS**

- LIMITED MOBILITY AND SITING FLEXIBILITY
- FEW CRITICAL NODES
- EASY TO FIND AND ATTACK
- EMP SOFT

While the SCILS system is conceived to operate with essentially any voice-bandwidth communication systems available, an emphasis in the program was placed on developing the ability to flexibly use single-channel (VHF or HF) radios. One reason for this emphasis was that earlier programs (e.g., SPADS) had emphasized the use of multi-channel phone systems. The primary reason, however, was the desire to explore the possibilities of benefiting from the inherent survivability advantages of single-channel radios over multi-channel phone systems.

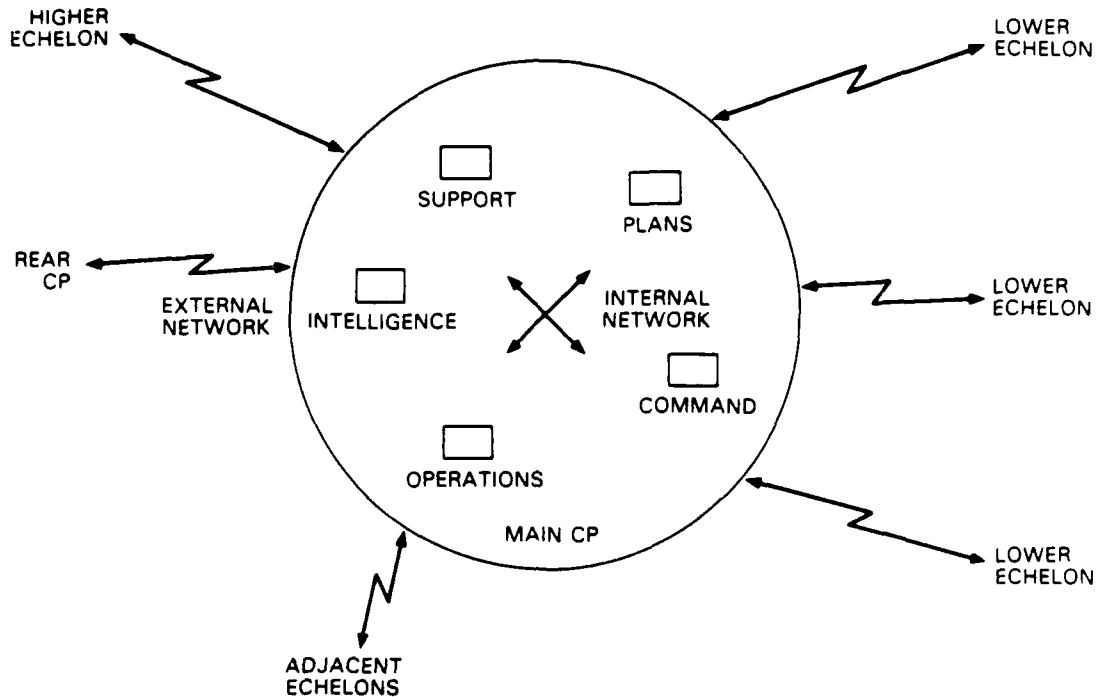
Since single-channel radios do not require line-of-sight for their operation, there is a high degree of siting flexibility and mobility in their use. In fact, it is well known that such radios can generally be used while in transit. Small physical size makes these radios relatively amenable to treatment for EMP effects. Finally, in considering the signature suppression issue, it is believed that individual single-channel radios are difficult to locate and identify on a battlefield where a large number of similar radios are in simultaneous operation. That is, even though individual radios are quite easy to detect, the user finds safety in numbers. This effect is enhanced astronomically as deployed radio technology moves towards widespread

frequency hopping and encryption utilization, since then a large number of radios may be operating simultaneously in the same frequency bands.

The Army tactical multi-channel equipment, on the other hand, utilizes relatively low power directional antennas in contrast to the "omni-directional" FM single-channel radios. As a result, the multi-channel equipment is more difficult to find due to the reduced electronic-signature from a SIGSEC viewpoint, but do have a larger physical signature from an OPSEC perspective. They are dependent on line-of-sight for their operation and as such there is less flexibility in their siting for employment. The aggregation of these assets into a small number of critical nodes makes them attractive targets which are, due to their radiation signatures, easier to find and attack. With their assemblages of unprotected equipment with large antennas, trailing wires, and cables, these systems are extremely soft to EMP effects.

However the real advantage to the use of single-channel radios for SCILS "video-conferencing" was their availability. A sufficient quantity of FM radios could be made available to support the dispersed "video-conferencing" whereas the multi-channel equipment was limited to "on-hand" quantities and no more. Therefore, multi-channel was adequate to support one command post, but not when it was dispersed into four separate locations requiring four sets of multi-channel equipment.

Chart 9. Typical echelon above corps configuration.



These considerations led to the concept of operation of a dispersed command post for a typical Echelon Above Corps headquarters which is depicted in the figure. In this configuration, the main CP is divided up into a number of cells. Although the cells are shown in the figure as being defined functionally, this is not necessarily the case. In assigning functions to cells, the effectiveness advantage of consolidating a given functional staff must be weighed against the desire for functional redundancy among the cells. In considering the communication problem, it seemed worthwhile to distinguish the needs for communicating internally among the dispersed cells from problems associated with communicating the longer distances to lower, adjacent, and upper echelons. In fact, the highly flexible networking approach ultimately implemented in the SCILS system has made the internal/external network distinction relatively unimportant. The following figures illustrate how this concept was adapted for implementation at the division echelon level and for testing at Fort Lewis.

SECTION 2

IMPLEMENTATION FOR THE 9TH ID AT FORT LEWIS

Chart 10. Division dispersed CP program.

- SURVIVABLE COMMAND INFORMATION AND LIAISON SYSTEM (SCILS)

- DEVELOPED BY DNA AT FT. LEWIS, WASHINGTON
(COORDINATED WITH U.S. ARMY DCCS PROGRAM)
 - ADP HARDWARE

 - SOFTWARE

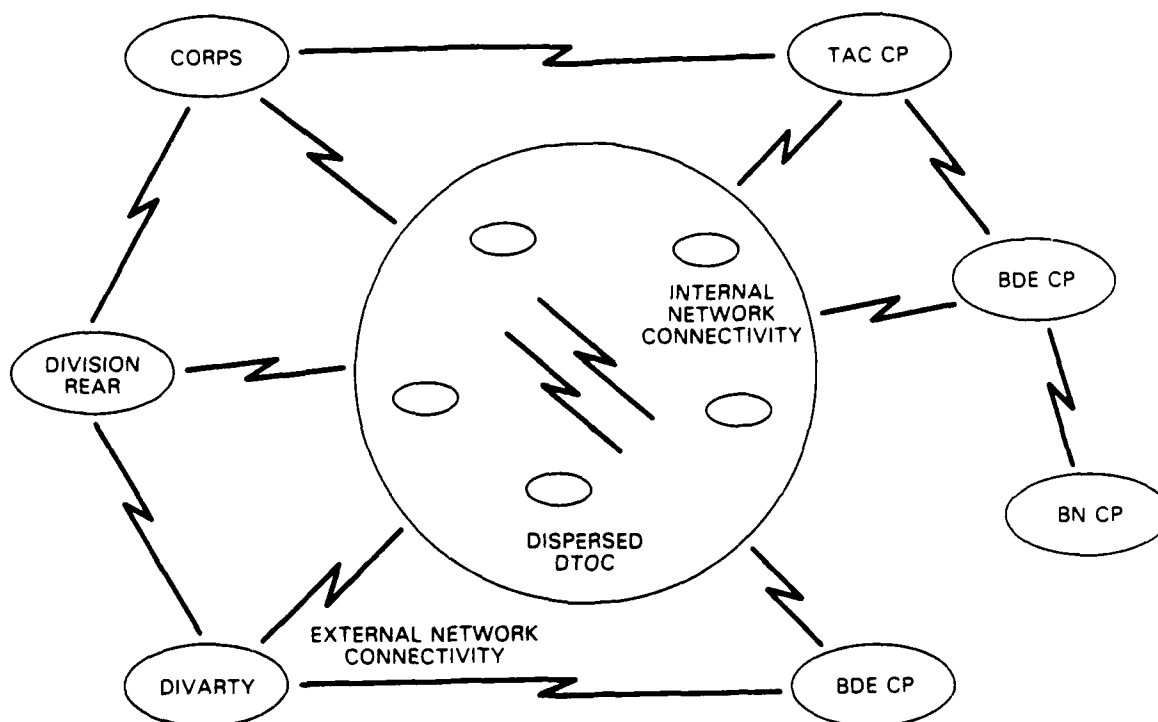
 - SYSTEM INTEGRATION
(INCLUDING COMMUNICATIONS)

 - TESTING THROUGH TROOP OPERATION

The 9th Infantry Division at Fort Lewis has a long-standing charter within the Army to investigate the use of high technology to enhance survivability and effectiveness, while maintaining a high capability for strategic mobility. This high-technology orientation made the 9th ID a highly suitable candidate for location of the SCILS program. A second major motivation for conducting the SCILS program at the 9th ID was the Army plan formulated at about the same time as SCILS, to develop their Distributed Command and Control System (DCCS) for the 9th ID. This provided the opportunity for DNA and the Army to coordinate the two programs to a common end. While there were some differences in the program orientations and technical approaches of the two programs, these were far outweighed by the similarities. The two programs found that they could use essentially the same ADP hardware, fully integrated and compatible software, and identical system integration configurations. In a

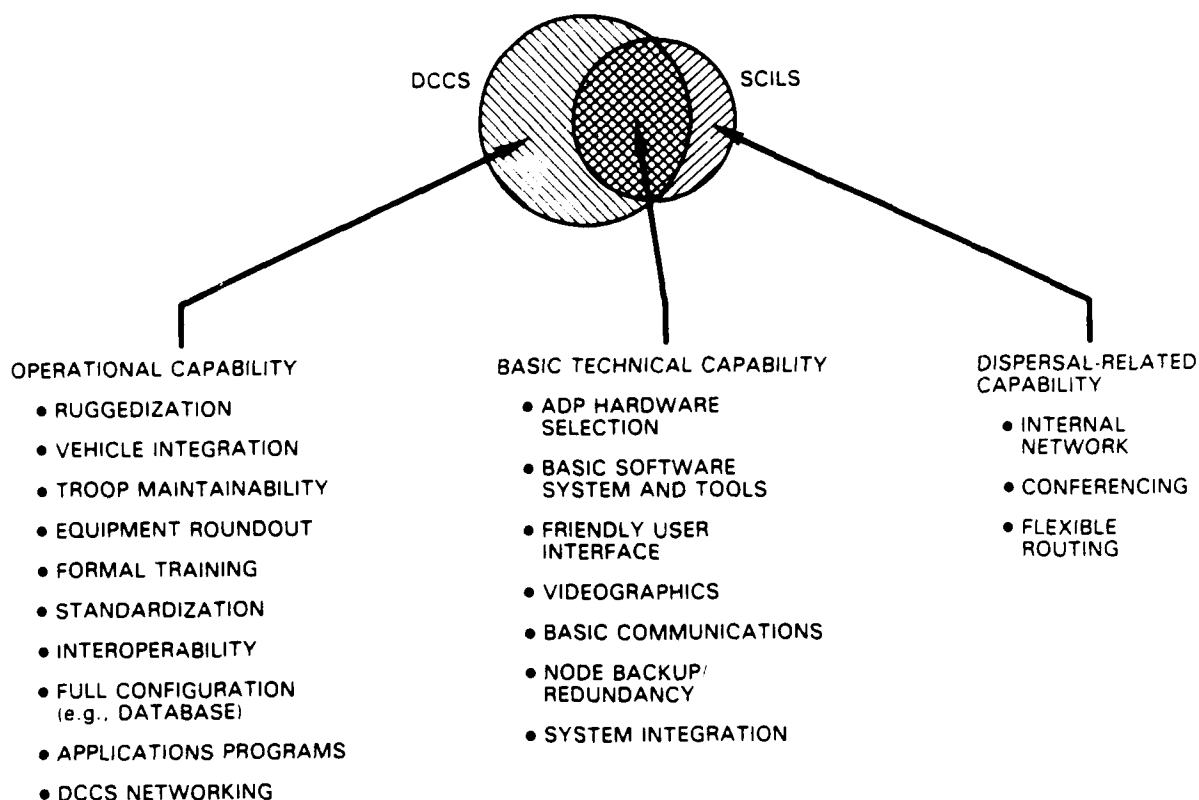
similar way, operator training activities and system testing through troop operation could benefit both programs. In this way both DNA and the Army could achieve far more for the resources expended than either could if the programs had been independent.

Chart 11. SCILS configuration.



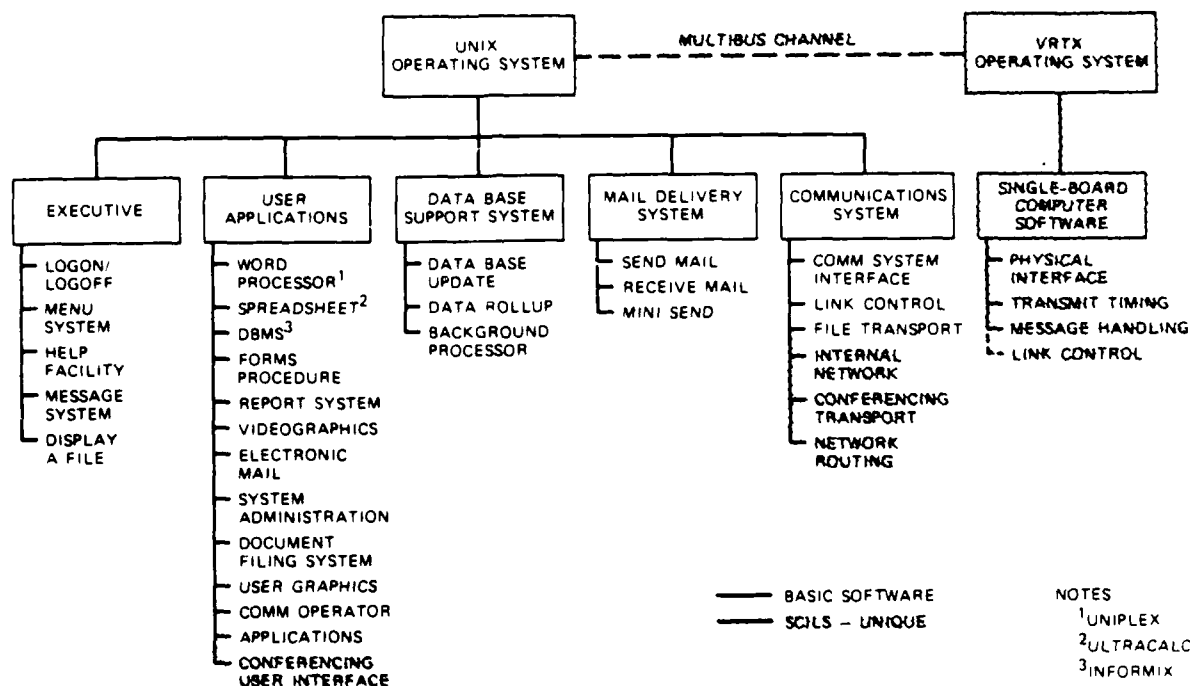
This figure shows the target SCILS configuration as it would be implemented at the 9th ID. SCILS system components would be located at the functionally-oriented cells of the Division Tactical Operations Center (DTOC) as well as at the Division Rear CP, Tactical CP, and at the Major Subordinate Commands such as the Brigade CPs and Divarty. These locations are naturally dispersed to distances on the order of tens of kilometers. In addition, when warranted by the threat and other operational factors, and when supportable in terms of logistics and security considerations, the Division's main CP or DTOC would be capable of dispersing its cells to further enhance Division C³ Survivability. In actual operations at Fort Lewis and elsewhere, the system has been operated with as many as 14 nodes in the field, most of them at relatively dispersed locations. While some very modest DTOC dispersions are commonly employed by the 9th ID, conditions have not permitted operation of a more fully dispersed DTOC. This has not had any negative impact whatsoever on the program's ability to achieve its experimental objectives, due to the availability of the much larger number of other fully-dispersed locations that had not been originally contemplated in the program.

Chart 12. SCILS/DCCS capabilities development.



This figure shows the overlap of the development objectives of the SCILS and DCCS programs. Most of the basic technical objectives of the two programs were common and could be developed in coordination by both programs. At the start of the two programs a very thorough ADP hardware and software evaluation was conducted in order to make recommendations to the Government to assist their selection process. Common hardware and commercial off-the-shelf software were selected for the two programs. A large portion of the new software that was custom developed for the two programs had requirements which would satisfy the needs of both programs. In these cases, the software effort was divided between the two programs in such a way as to result in a single integrated software system output. Similar remarks also apply to the basic hardware/software system integration effort.

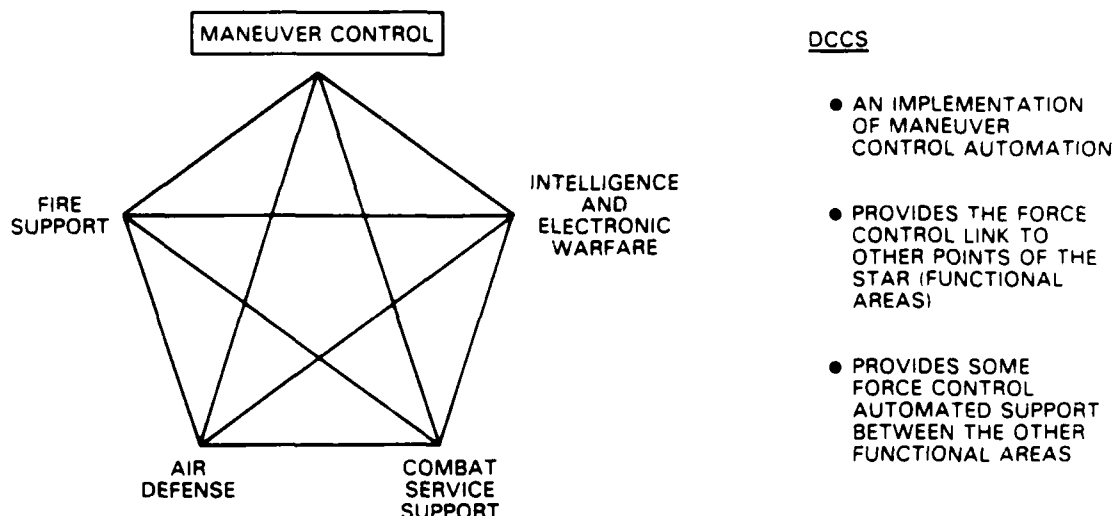
Chart 13. Integrated software architecture.



This figure provides an overview of the architecture of the DCCS/SCILS software system. As stated earlier, the software developed by the two programs was designed to be compatible from the start. The shaded areas show those parts of the software which were considered to be SCILS unique (i.e., not of initial interest to the DCCS program). Most of these SCILS-unique developments have been adopted by the Army for integration into the operational DCCS system.

Since the goal of the DCCS program was to develop an operational C³ system for the 9th ID (while SCILS is basically an experimental program) there were many activities that DCCS needed to undertake on its own. These are listed in the figure. Also shown are a number of technical objectives that were essential to the SCILS program but (at least initially) of much less interest to the DCCS program. These were the objectives that were most closely focused on achieving a dispersal-related capability. These SCILS-unique objectives are discussed at some length below.

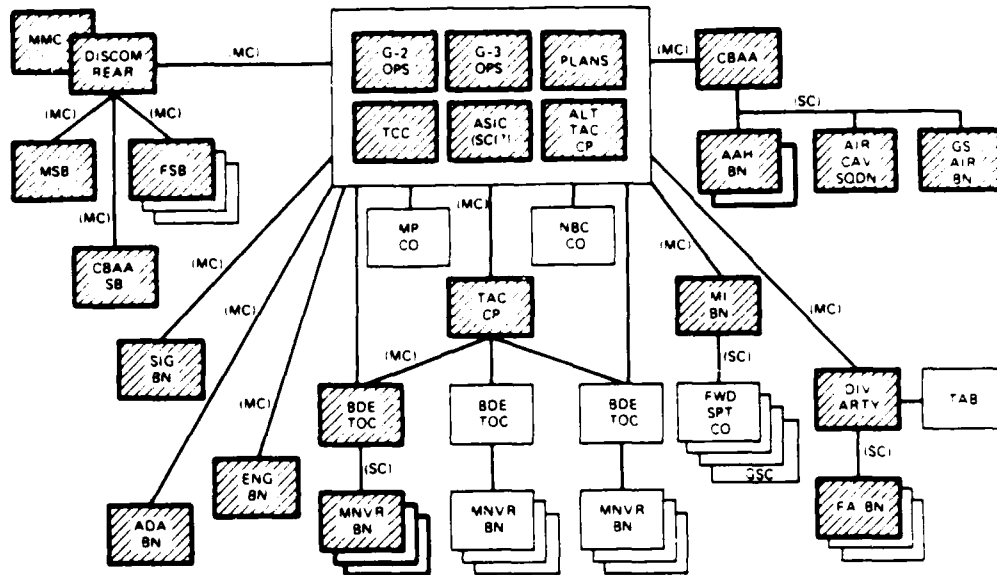
Chart 14. DCCS and the command and control architecture.



In order to understand the impact (both realized and potential) of the SCILS program on C³ developments within the U.S. Army, it is necessary to understand how the DCCS developments relate to the overall command and control architecture expressed in Army planning documents. Within the Army, the five functional areas shown each have separate but coordinated C³ development activities. DCCS represents an implementation of maneuver control automation. At the same time, the system is capable of providing both links and limited automation support to the other functional areas.

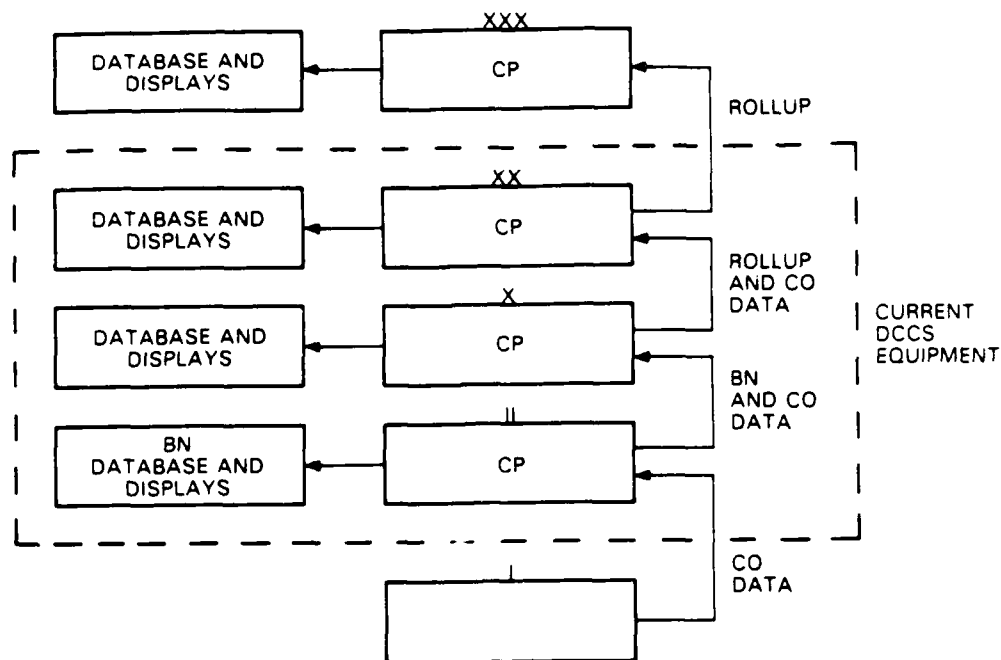
DCCS has already had and will continue to have a strong impact on the development of the Army-wide Maneuver Control System (MCS). It is through this technology transfer from the DCCS to MCS programs that SCILS has had and will continue to have a strong impact on the survivability and effectiveness of Army-wide C³ operations and capabilities.

Chart 15. Hardware allocation (9th ID).



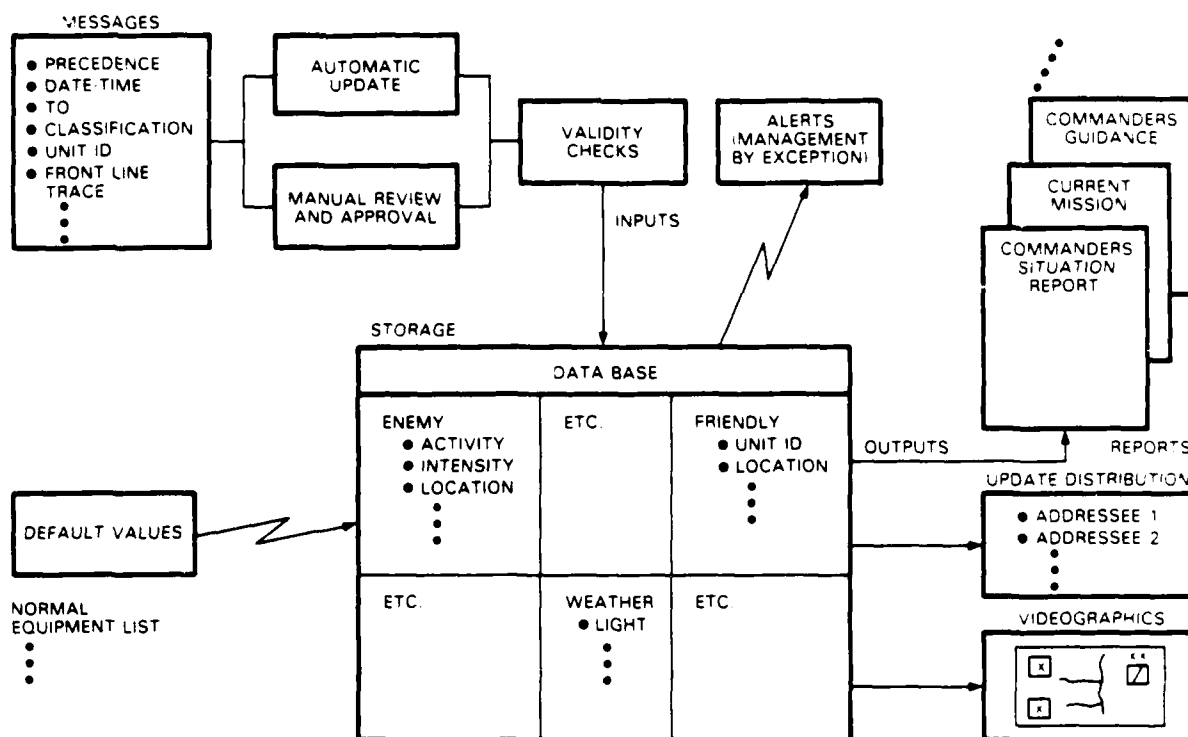
The DCCS system at the 9th ID extends from the Division echelon level down to the Battalion level. Components at the Division level and major subordinate commands use common hardware and software, while the components at lower echelons use a compatible but different configuration. Thus, the SCILS-developed capabilities were implemented in the upper echelon component of the DCCS while maintaining compatibility with the lower echelon component. The upper echelon component has been deployed at 14 nodes within the 9th ID.

Chart 16. SCILS/DCCS information flow.



In support of maneuver control, information in the data base generally flows from lower echelon to upper echelon as shown in the figure. The relational data base supported by the SCILS/DCCS system contains an extensive set of data elements at each echelon level, representing the status of equipment and personnel. As information flows from lower to upper echelon in the system, it is automatically rolled up by the data base system at the higher echelon. In this way, for example, the status of a Brigade depends upon the super-position of inputs received from its subordinate battalions, and so forth. This data base rollup is performed automatically by the system every time new information comes in, maintaining a currency in the available information which would not otherwise be attainable.

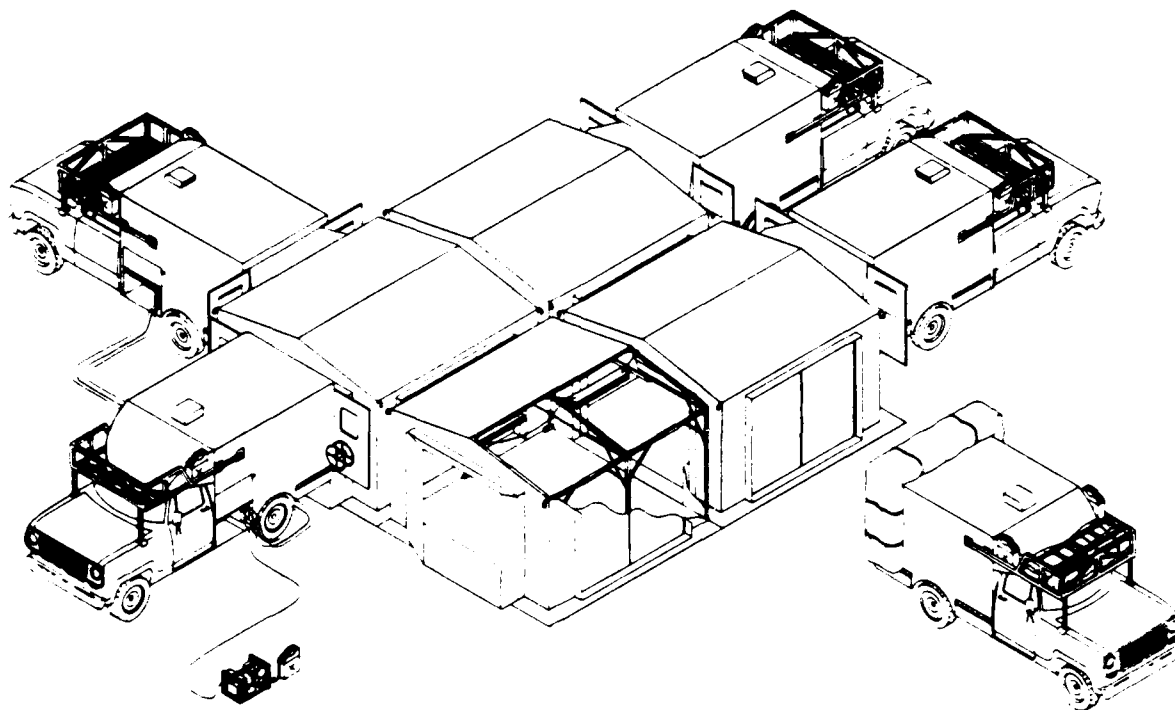
Chart 17. SCILS/DCCS relational data base management system.



However, rollup is only one aspect of the highly capable SCILS/DCCS data base system. Some additional capabilities are illustrated in this figure. Messages and data base updates from other nodes can be subjected to manual review and approval, if desired, before entry into the local data base. However, normally such updating is performed automatically. Whenever a data base change is performed at a node, based on manual inputs or as a result of rollup of incoming updates from lower echelons, the resulting data base change is distributed automatically to all of the redundant upper echelon nodes in the system using a multiple-addressed message.

The system also automatically maintains a large set of reports which comprise the Commander's Decision Display System. Foremost among these is the Commander's Situation Report, which is primarily graphically oriented, and is capable of showing the Division status as a whole or in terms of its component parts down as far as the Company level. Finally, information from the data base is extracted automatically and displayed on the video-graphics portion of the system which maintains the map representations required by the users.

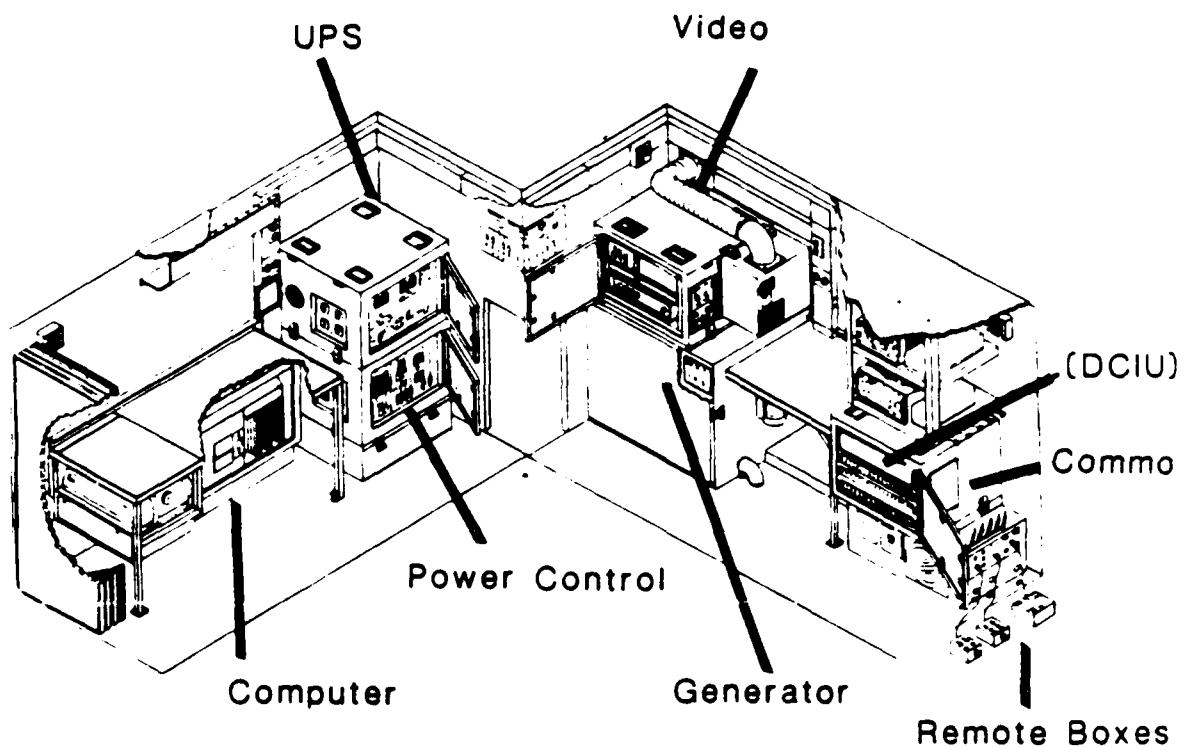
Chart 18. Integrated Command Post - Modular Concept.



When the 9th ID goes to the field with the SCILS/DCCS system for a CPX or FTX, a typical deployed node might appear as shown in the figure. The basic deployment module consists of a single C³ vehicle with its integrated tent structure. These modules may be combined with a high degree of flexibility, depending upon the node application and the operating conditions.

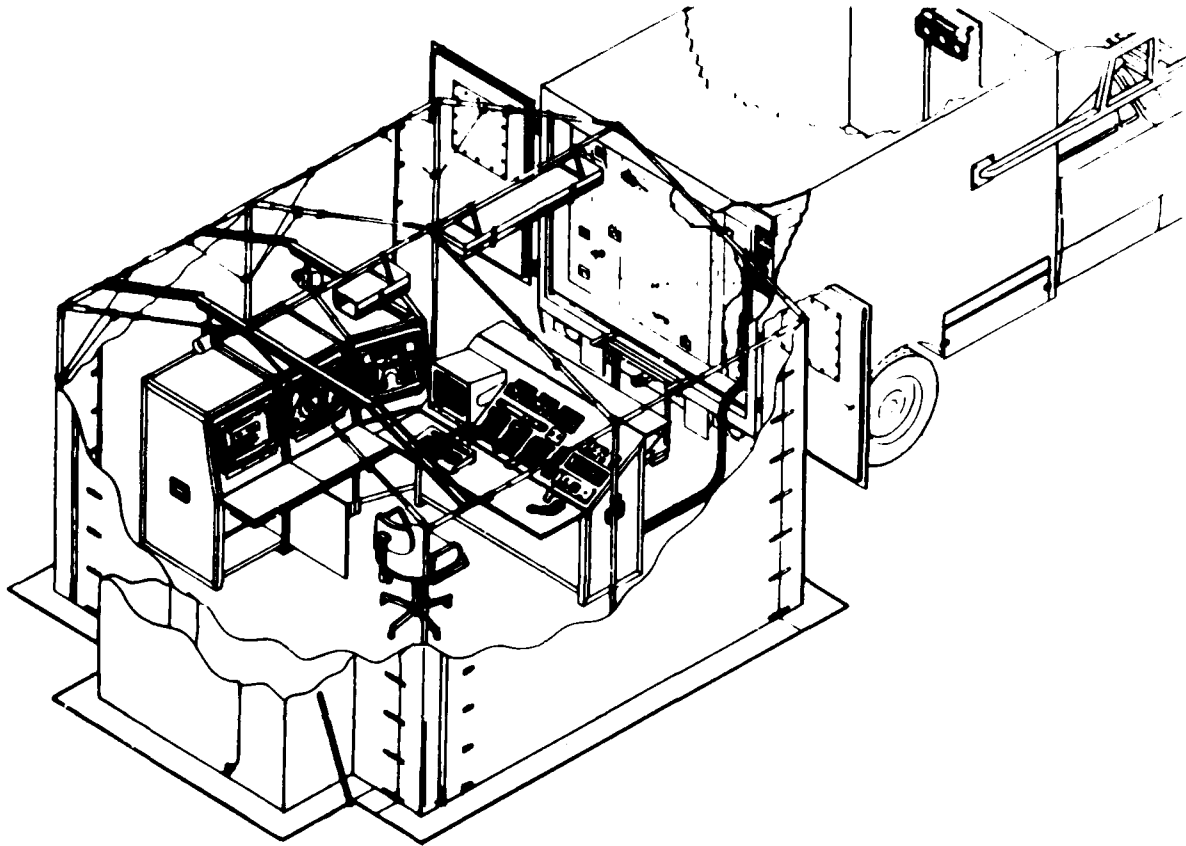
The 9ID currently uses an "evolutionary mix" of Integrated Command Post Vehicles (ICPS). The M886 depicted on this page was a "first generation" ICPS. The current mix consists of M886, M1010 (2nd generation) and HMMWV modular ICPS. In a node such as is shown in the figure, only one of the vehicles would be equipped with the ADP equipment. The other vehicles would be used to carry other required equipment and personnel. Since the overall design of the field support equipment accommodates not just the ADP requirements but indeed the complete set of requirements necessary for the support of C³ operation in the field, the result is referred to as the "Integrated Command Post."

Chart 19. ICP vehicle configuration.



This figure depicts an interior view of the M1010 ICPS. Although the configurations vary between the M886, M1010 and HMMWV, which are all found in the 9ID, this is representative of the ICPS approach to the ICPS layout. This would represent the ICPS vehicle at a given node, which contains the ADP equipment. Note that the computer, the communications equipment, and the power conditioning and control equipment remain in the vehicle during operation. Other equipment such as the terminals and displays are stowed in the vehicle for transport and can be operated while within the vehicle to a limited extent. However, it is more typical for the terminals and displays to be deployed out into the tent for tactical operations.

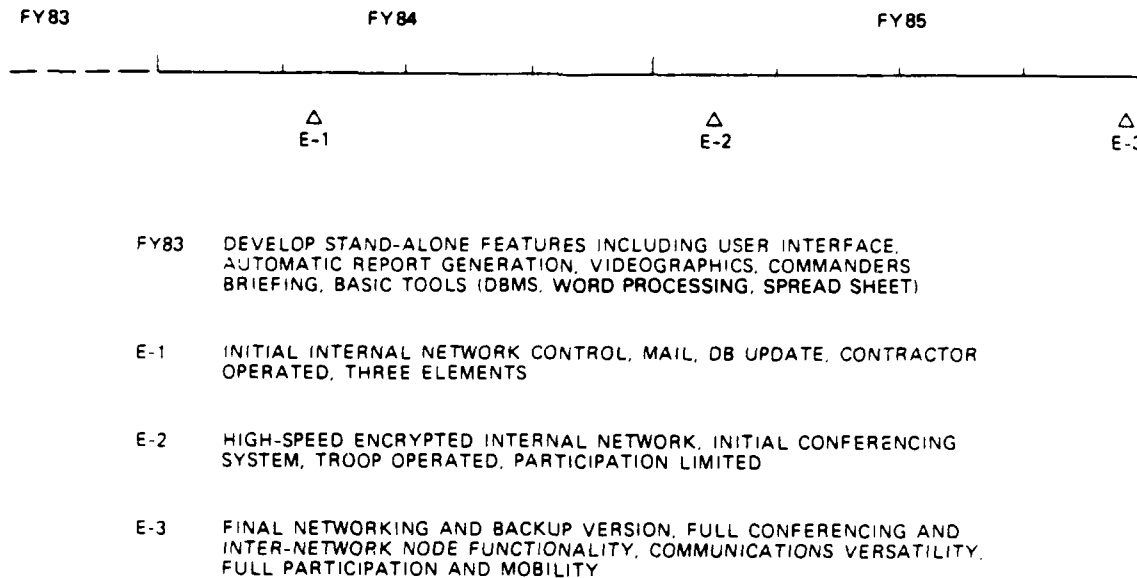
Chart 20. Commander's battle center.



A special configuration of the DCCS system was developed for the 9th ID Commanding General and is referred to as the "Commander's Battle Center". This configuration integrates the SCILS/DCCS system with additional display and communications capabilities and a highly flexible control console.

In operation, a large screen display is erected in the back of the vehicle. This display can be switched between the SCILS/DCCS videographic subsystem output and other video sources. Ordinary terminal and RGD monitor displays are also provided, of course. Note that for transport all of the equipment shown is stowed in the one vehicle, and can be deployed or stowed in minutes.

Chart 21. SCILS evolution plan.



Since SCILS was an experimental program, formal acceptance testing would have been inappropriate and was not performed. However, in addition to on-going testing, demonstration, and user-feedback sessions, there were three major experiments planned for the program, as shown in the figure. The E-2 experiment was troop operated, but was independent of the 9th ID's exercise schedule. However, the E-3 experiment was conducted as an integral part of the Cascade Peak CPX conducted at Ft. Lewis. At each of the experiments, the system was found to perform as expected, corresponding to the stage of development at that time.

As SCILS features matured during the program and were integrated into DCCS, they were fully exercised at every 9th ID CPX and FTX. By the end of the SCILS program, the SCILS conferencing and multi-media networking systems were integrated into the DCCS system and were being used routinely in every 9th ID exercise.

SECTION 3

TECHNICAL OVERVIEW OF THE SCILS SYSTEM

Chart 22. SCILS technical highlights.

- COMPUTER CONFERENCING
 - MATERIALS PREPARATION, SPEAKER CONTROL, DISPLAY CONTROL, ON-LINE MESSAGES
 - HIGHLY EFFICIENT USE OF MODEST DATA-RATE COMMS
- MICROCOMPUTER-CONTROLLED NETWORKING
 - DARPA-NET INSPIRED PACKET-SWITCHING APPROACH
 - MINIMUM COST ROUTING
 - ADAPT TO CONNECTIVITY CHANGES
 - MIXED PHONE AND RADIO TYPE COMM MEANS
 - TIME-SHARED BROADCAST CHANNEL ACCESS
 - SLOTTED AND DEMAND ACCESS
 - COMM FRONT END ARCHITECTURE
 - IMPLEMENTATION WITH EXISTING BATTLEFIELD COMMS

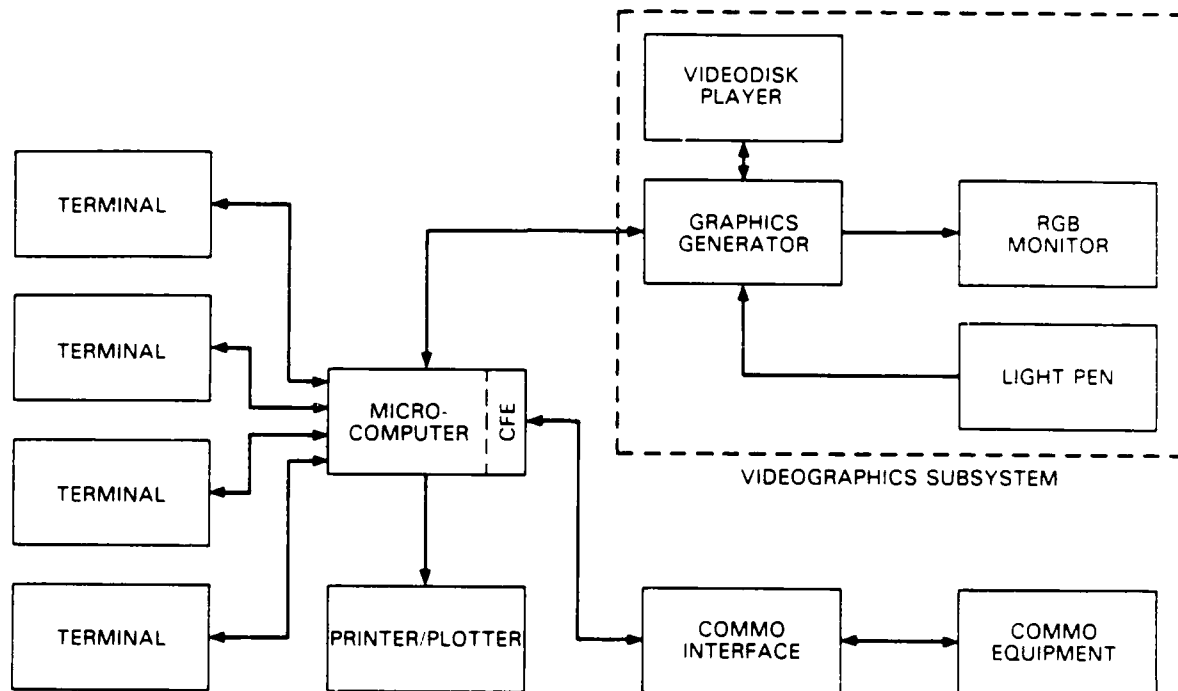
This section provides some additional detail on two of the more original and technically innovative aspects of the SCILS program. These are the voice/data conferencing and the data networking subsystems.

Voice/data conferencing provides a highly sophisticated and effective coordination mechanism that can be used by two or more operators at essentially any locations within the dispersed system. The conferencing system supports preparation of conferencing materials (e.g., map overlays) and the distribution of these materials prior to a conference in a highly user-friendly fashion. Once a conference is initiated, the system has provisions for speaker control (a mechanism for the orderly transition from speaker-to-speaker during the conference) and display control (synchronization of the videographics displays

at the conferee locations). The system also provides a comprehensive on-line message system exercised through the conferees' terminals. In all phases of system operation, the computers make extremely efficient use of the available inter-computer data rates, which are assumed to be no more than 1200 bits per second (as contrasted with CCTV systems which require extremely wide bandwidths).

The SCILS networking system is designed to operate with the existing battlefield communications organic to the 9th ID. The overall networking system includes a "multi-media" packet-switched network capable of operating with essentially any mixture of link types on the battlefield (including phone, radio, TACSAT, wire, etc.). The SCILS program also developed an "internal network" system for the highly efficient time-shared use of a single broadcast channel on VHF or HF radio. This efficient time-sharing approach was made possible by the use of a "communication front end" architecture in which channel access is controlled by a single board computer (SBC, installed on the bus of the main system micro-computer. This SBC is dedicated to running the time-critical communications software under a real-time operating system, leaving the main system microprocessor free to support other required system functions under a time-sharing operating system. Although the Single Board Computer was developed and tested in the lab, it was not used on any of the 9ID exercises or tests. RS 232 wire interconnection and the DCCS communications front-end box, DCIU (data communications interface unit) were used during the various exercises and tests of the system.

Chart 23. SCILS ADP configuration.



This figure shows a typical ADP configuration for a SCILS node. The main system micro-computer runs the UNIX time-sharing operating system, typically supporting four user terminals. These terminals are the principal means for user interface to the system. In order to make this interface as user-friendly as possible, it is largely menu driven. Where textual information from the user is required, a custom developed "forms processor" interface provides the means whereby the user supplies the information by a mechanism similar to filling out a paper form.

The videographics subsystem is primarily used to display military maps (or other graphics output) on the color monitor. A large set of maps (on the order of 50,000 frames) for a given region (and other visual material such as photographs) is stored on a video disk. The graphics generator controls the video disk player, based on user inputs, to display the correct map frame. At the same time, the graphics generator generates and displays the overlay graphics indicating typical military

symbology for friendly and enemy unit locations, phase lines, range fans, etc. The system supports a large repertoire of graphics functions for creating desired overlays, can be totally light-pen driven, and is extremely user-friendly.

The final major element of the SCILS ADP system is the communications interface subsystem. Two methods of communications interface are supported by the SCILS system. The first one uses the DCCS Communications Interface Unit (DCIU), which is connected to the micro-computer over a 19.2 kb/s RS-232 link. The second method uses the communications front end, consisting of an internally-mounted single-board computer, with interface circuitry that permits direct connection to the communications systems. (This latter approach has not been adopted yet for use by the 9th ID.)

The specific equipment used in the system was jointly selected with the U.S. Army (the same equipment is used in DCCS), and includes the WICAT 160 microcomputer (discussed further below), Ann Arbor Ambassador terminal, and the Okidata Microline 93 printer. The components of the videographics subsystem include the Graphover 9500 graphics generator from New Media Graphics, the Aydin 19-inch RGB monitor (model 8830) and the Sony LDP1000A videodisc player.

Chart 24. WICAT system 161 characteristics.

- RECONFIGURED TO ONE-DRAWER CONFIGURATION

- SIZE: 8 x 17 x 26 IN (2.1 FT³)
- WEIGHT: ABOUT 35 LB

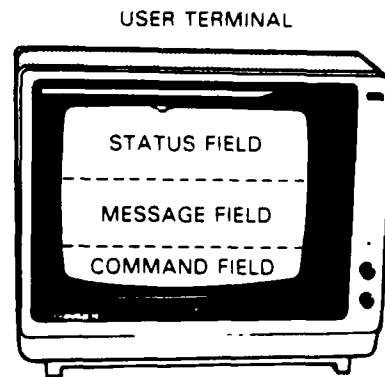
- FEATURES

- MOTOROLA 68000 PROCESSOR
- 1-2 MB RAM
- 39 MB HARD DISK
- TAPE DRIVE BACKUP

The original micro-computer selected by the Government for the SCILS and DCCS programs was the WICAT system 160, with features shown in the figure. This computer was designed for office use but was readily installed in vehicles for field use by the 9th ID and proved to be quite able to withstand the rigors of such use. In order to use available space more efficiently, the office-configured computer was repackaged for the DCCS program to a one-drawer configuration (the WICAT system 161) which was more compact, required less room in the vehicles, and eased the frequent transition of the ADP equipment between the field (i.e., installed in the vehicles) and garrison (i.e., installed in buildings) configurations.

Chart 25. Voice/data conferencing.

- OFF-LINE (PREPARATION) CAPABILITIES
 - DEFINE CONFERENCE — NAME CONFERENCE, CONFEREES, LEADER
 - PREPARE CONFERENCE — FILE GRAPHICS (AUTOMATICALLY DISTRIBUTED)
 - INITIATE CONFERENCE — BRINGS CONFEREES ON-LINE
- CONFERENCE CONTROL CAPABILITIES
 - STATUS
 - NAMES OF CURRENT CONFERENCE, LEADER, SPEAKER, GRAPHICS FILE
 - LIST OF CONFEREES, THEIR LINE STATUS (NOMINAL, DEGRADED, DOWN), AND REQUEST TO SPEAK (NONE, ROUTINE, CRITICAL)
 - COMMANDS
 - LEADER DESIGNATES SPEAKER, CAN DROP CONFEREE, TERMINATE CONFERENCE
 - CONFEREES CAN REQUEST TO SPEAK WITH URGENCY MEASURE
- ON-LINE MESSAGE SYSTEM
 - SCROLLING ON-LINE MESSAGE DISPLAY (WITH RECORD SWITCH)



The next two charts (pages 28 and 30) describe the voice/data conferencing system. Before the start of a conference, the users can prepare for the conference by using the preparation capabilities of the system. A specific conference can be defined by name, with a list of conferees and a specified leader for the conference. Materials (such as map overlay graphics) can be prepared for the conference in advance. When a preparer files these materials in the conference file they are automatically distributed to the other conferee locations. At any time, the conference leader can initiate a conference through the corresponding menu selection at his terminal. This selection starts a chain of events on the network which results in bringing the other listed conferees on-line for the conference.

Once a conference has been initiated, the system provides the conference control capabilities necessary to maintain the smooth flow of information during the conference. Every conference has a conference leader. Through selection of the

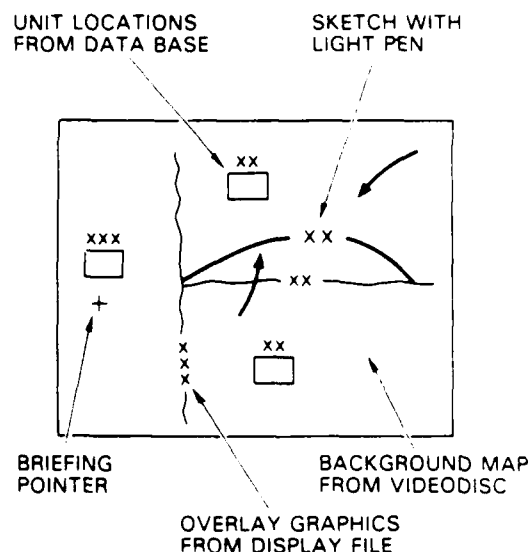
corresponding menu options at his terminal, the leader can designate the next speaker in the conference, can drop a conferee when necessary and, when the conference is concluded, can terminate the conference. Only one conferee can speak at a time during the conference. Conferees can request to speak at any time through the corresponding menu selections at their terminals, and can assign an urgency measure to this request. The resulting conference status at any time is displayed in the status field of the conferee terminals.

Also shown on the conferee terminals is a message field used in the on-line message system provided by voice/data conferencing. This message system permits the conferees (not just the speaker) to exchange messages during the conference without disrupting the flow of information from the speaker. Message traffic can be logged, if desired, for later replay. When communications on the battlefield become too limited to support separate voice communications, the on-line message system provides a rapid means of information exchange that is always available as long as connectivity with the multi-media network is maintained.

Chart 26. Voice/data conferencing (continued).

● GRAPHICS DISPLAY CONTROL CAPABILITIES

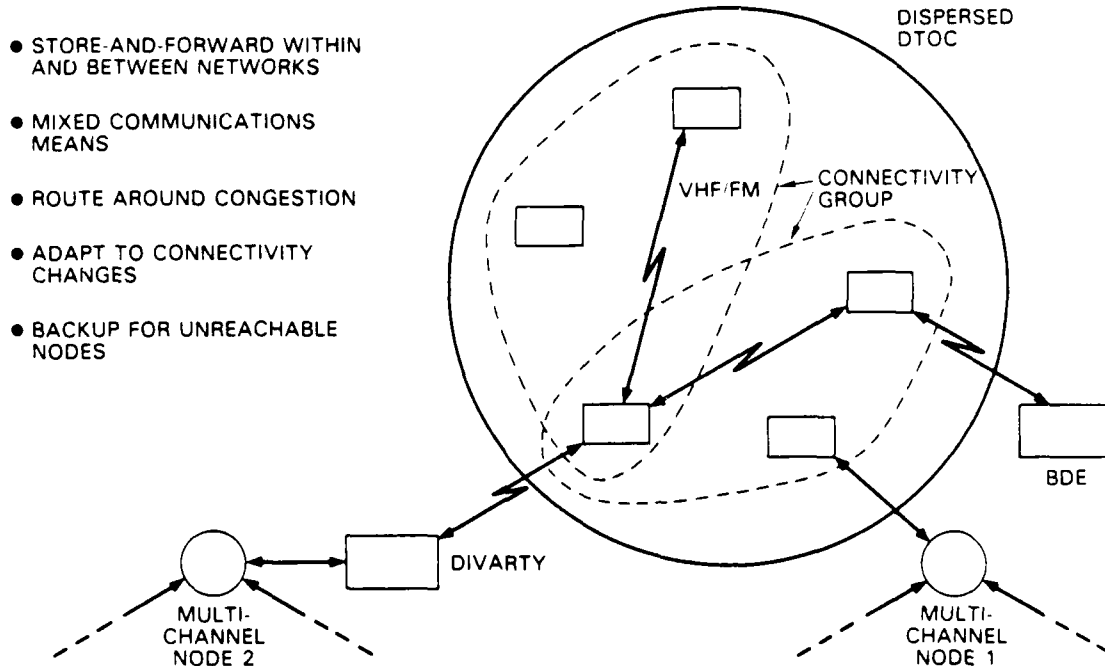
- SPEAKER HAS CONTROL OF ALL CONFEREES DISPLAYS "SIMULTANEOUSLY"
- ESSENTIALLY ANY GRAPHICS FEATURE IN SYSTEM CAN BE USED
- SPEAKER CAN RECALL PRE-DISTRIBUTED GRAPHICS, MODIFY GRAPHICS, GENERATE NEW GRAPHICS, MOVE BRIEFING POINTER, ANNOTATE WITH TEXT
- USES COMMUNICATIONS WITH HIGH EFFICIENCY



The speaker, during a conference, exercises simultaneous control over the graphics displayed at all of the conferee locations. This permits him to communicate information to other conferees through graphics, while he speaks to them over the voice medium (e.g., either phone or single-channel radio). The speaker exercises control over the graphics at his location using the same capabilities and the same commands as are used in the stand-alone (i.e., non-conferencing) mode of operation. For example, the speaker can change the map location or scale displayed, can recall overlays that were prepared and distributed before the conference, can modify these overlays, generate new graphics and so forth. Soon afterward, the other conferees see these graphics changes at their own displays. This conferencing capability provides a highly flexible and powerful briefing or coordination tool, which operates without regard to the location of the conferees.

It is important to understand that the display contents are never directly communicated in this system. Since a typical RGB color display contains about a million bits of information, a brute force approach would be very time consuming and inefficient. Instead, the system communicates display information through the high-level commands which are used in the system to define a given display. Then, copies of the required display are generated locally from these commands. This approach permits the system to operate with the same modest data-rate communications that are used throughout the rest of the SCILS system.

Chart 27. Multi-media network.



The SCILS system includes a packet-switched data networking capability referred to as the "multi-media" network to reflect its ability to work with essentially any communication links available on the battlefield. As in any packet-switched network, there is no need for a direct connection between the origin and destination of a data message, since a message can be transferred by store-and-forward procedures by any number of intermediate nodes. Essentially any combination of link types along the route is permissible and, of course, multiple links between nodes are permissible.

The SCILS system at each node learns of its connectivity to the outside world through a manually-input "route-table," which specifies the nearest neighbor nodes and the available link types to those nodes. This information is then distributed throughout the network by each node, so that every node eventually has an (ideally identical) picture of the global network connectivity. Then, whenever a message needs to be sent from an origin node to a destination node, a routing calculation is performed which computes the minimum-cost route between the

nodes. Then the message is transmitted over the link to the next node along that route. If the network connectivity changes, as would be expected on a dynamic battlefield, the system automatically adapts by choosing from among the routes available at the time. Finally, in cases where nodes are temporarily unreachable, the network saves the message traffic pending reconnection of the disconnected nodes.

Chart 28. Internal network.

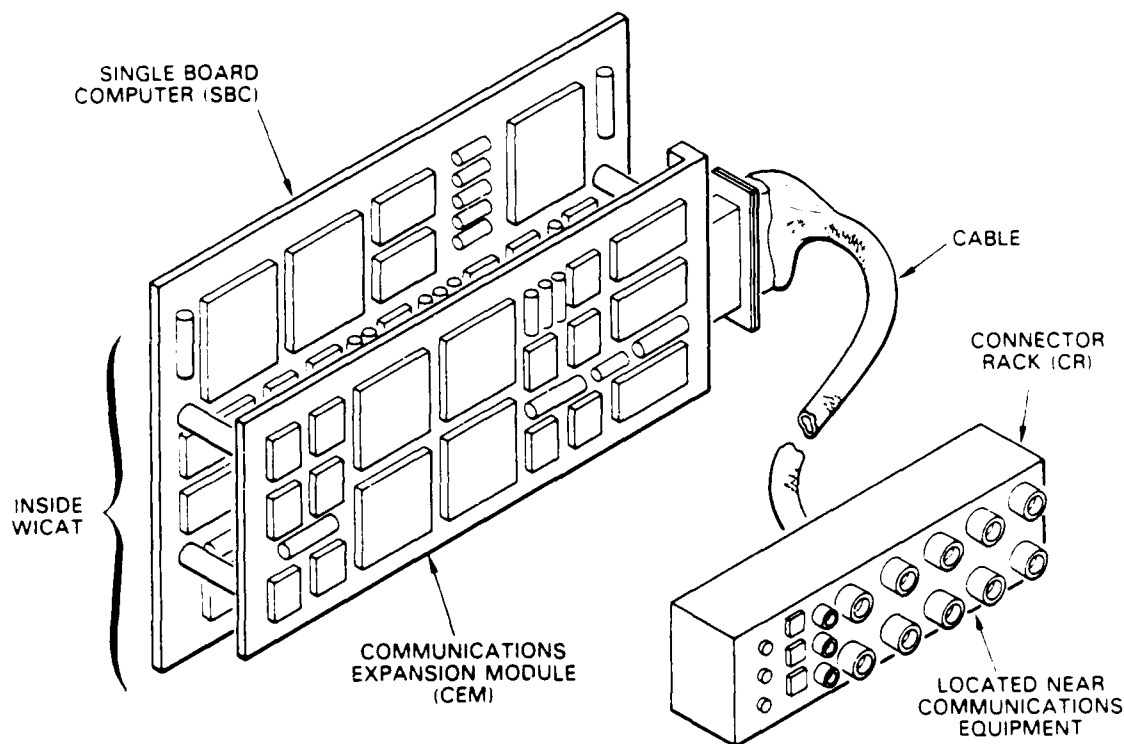
- SINGLE TIME-SHARED VOICE-CAPACITY CHANNEL
- DATA CONNECTIVITY WITHIN DISPERSED DTOC (EXTENDABLE)
- SINGLE-CHANNEL RADIO ORIENTATION
- OTHER COMMS POSSIBLE
- SLOTTED ACCESS AND DEMAND ACCESS OPTIONS

The internal network was developed as a special-purpose component of the multi-media network. This component permits a number of dispersed nodes to time-share a single voice-capacity channel on any broadcast medium, such as VHF or HF single-channel radio. (The internal network system is capable of working with other communications systems such as TACSAT.) While the original motivation for developing the internal network was to provide an efficient and highly survivable means of maintaining data connectivity within a dispersed DTOC, the capability is potentially useful in any situation where multiple dispersed nodes need to efficiently use the sparse communication channels available on the battlefield.

Two different algorithm types were developed for controlling node access to the internal network. In the slotted-access approach, each node on the network has a dedicated time slot in which it may broadcast its message traffic. In demand-access, there are no dedicated time slots, but instead each node is permitted to transmit at any time the channel is observed to be quiet. (A method is provided for resolving collisions.) Under moderate message traffic conditions, the demand-access algorithm

is probably preferable, since it avoids any pattern of transmissions which might conceivably facilitate communications traffic analysis by an enemy. The slotted-access approach is, however, preferable in conditions of heavy message traffic, since it's capable of providing a much higher efficiency of channel time-line utilization.

Chart 29. SCILS communications front end (CFE).



The internal network is supported by the SCILS communication front end (CFE) which is depicted in artist's concept in this figure. The heart of the system is a single board computer (SBC) which is installed inside the WICAT computer in one of the empty bus slots. The SBC is itself a quite powerful computer employing an MC68000 micro-processor and as much as 256 KByte of RAM as well as various input/output ports. The SBC interfaces directly to a Communication Expansion Module (CEM) which includes the devices (modem chips, auto dialers, digital level converters, etc.) necessary to interface to the various communications systems of interest. The physical connection to the communications systems is supported by a connector rack located near the communications equipment at the end of a cable run from the computer.

The SCILS internal network and communications front end were fully developed and thoroughly tested both in laboratory engineering tests and field tests at Fort Lewis. Little has been done, however, to integrate this capability into the DCCS. Since the Army has shown a much greater interest in the SCILS voice/data conferencing system and multi-media network, these other objectives were emphasized in the program, somewhat at the expense of additional work on the internal network.

Chart 30. Conclusions and recommendations.

- ALL TECHNICAL GOALS OF PROGRAM ACHIEVED
- MAJOR IMPACT ON ARMY C³ ACCOMPLISHED
- STATE OF ART FOR SURVIVABLE AND EFFECTIVE C³ FOR THEATER FORCES HAS BEEN ADVANCED
- RECOMMEND
 - BRIEFING PROGRAM RESULTS AT ACE HEADQUARTERS
 - DEMONSTRATE SYSTEM OPERATION IN THE THEATER

The SCILS internal network and communications front end (CFE) were developed and tested in the laboratory. However, to utilize the SBC and CFE it necessitated the removal of some of the DCCS computer and communications hardware and the installation of these items. As this was time consuming and too much work to cohabit with the DCCS hardware and software, it was never fully exploited. Since the Army showed a much greater interest in the SCILS voice/data conferencing system and multi-media network, these other objectives were emphasized in the program, somewhat at the expense of additional work on the internal network.

DISTRIBUTION LIST

DEPARTMENT OF DEFENSE

DEFENSE ADVANCED RSCH PROJ AGENCY
ATTN: LIBRARY

DEFENSE COMMUNICATIONS AGENCY
ATTN: CTR FOR C3 SYS

DEFENSE INTELLIGENCE AGENCY
ATTN: RTS-2B

DEFENSE NUCLEAR AGENCY
ATTN: OPNA
4 CYS ATTN: TITL

DEFENSE TECHNICAL INFORMATION CENTER
12 CYS ATTN: DD

DEPARTMENT OF THE ARMY

ARMY DEVELOPMENT & EMPLOYMENT AGENCY
ATTN: C3I DIV

ASSIST CHIEF OF STAFF FOR AUTOMAT/COMM
ATTN: ASST CHIEF OF STAFF

DEFENSE COMMUNICATIONS SYSTEMS
ATTN: PROJECT MANAGER

VI CORPS & FORT LEWIS
ATTN: COMMANDER

REMOTELY MONTRD BATFLD SENSOR SYS
ATTN: PROJECT MANAGER

RESEARCH & DEV CENTER
ATTN: COMMANDER

US ARMY COMMUNICATIONS COMMAND
ATTN: COMMANDER

US ARMY SIGNAL CTR & FT GORDON
ATTN: COMMANDER

9TH INFANTRY DIV & FT LEWIS
ATTN: COMMANDER

DEPARTMENT OF DEFENSE CONTRACTORS

BDM CORP
ATTN: J BRADDOCK

INSTITUTE FOR DEFENSE ANALYSES
ATTN: A DEICHMANN
ATTN: CLASSIFIED LIBRARY
ATTN: VUTGOFF

KAMAN SCIENCES CORPORATION
ATTN: DASAC
ATTN: R MAHONEY

KAMAN TEMPO
ATTN: DASAC

PACIFIC SIERRA RESEARCH CORP
ATTN: H BRODE, CHAIRMAN SAGE

R & D ASSOCIATES
2 CYS ATTN: G GORDON

R & D ASSOCIATES
ATTN: A DEVERILL
ATTN: C KNOWLES

66TH MI GROUP
ATTN: R & D ASSOCIATES
2 CYS ATTN: RDA-E

Dist-2

END

DATE

FILMED

5-88

DTIC